

# *THELYMITRA EPIPACTOIDES* F. MUELL. (ORCHIDACEAE): THE MORPHOLOGY, BIOLOGY AND CONSERVATION OF AN ENDANGERED SPECIES

S. C. CROPPER,<sup>1,2</sup> D. M. CALDER<sup>1</sup> AND D. TONKINSON<sup>3</sup>

<sup>1</sup>Botany School, University of Melbourne, Parkville, Victoria 3052.

<sup>2</sup>Present address: National Parks and Wildlife Division, Department of Conservation, Forests and Lands,  
1/250 Victoria Parade, East Melbourne, Victoria 3002.

<sup>3</sup>Botany Department, La Trobe University, Bundoora, Victoria 3083.

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*Thelymitra epipactoides* F. Muell. (metallic sun-orchid) was once widespread in coastal regions of south-eastern Australia but extensive clearing of habitat and collection by orchid enthusiasts has resulted in a significant reduction in its distribution. At present seven small populations (2–250 adult plants) survive on public land. Before adequate management procedures can be developed a better understanding of the species and its biology is required.

Variation in floral and vegetative characters and the phenology of *T. epipactoides* are described. The population structure and major threats at three Victorian sites are considered; heavy grazing by chrysomelid beetle larvae, tortricid moth larvae and rabbits is recognised as a major threat to these populations. Evidence suggests that the lack of occasional summer-autumn fires is also contributing to the decline of the species. Fire apparently reduces competition with dominant shrubs and grasses, and increases seedling recruitment through the promotion of flowering, leading to increased seed set. Fires also create open sites suitable for seedling establishment. The lack of pollination and seed set at coastal sites in recent years is a long term threat to these populations.

*THELYMITRA EPIPACTOIDES* (metallic sun-orchid) was once widespread though never common in coastal regions of Victoria and South Australia (one specimen in the National Herbarium of Victoria has been recorded from Bulli in New South Wales). Extensive clearing of habitat and collection by orchid enthusiasts have resulted in a large reduction in its distribution. Leigh et al. (1984) considered the species to be endangered. With the three largest populations in Victoria now located in conservation reserves, suitable management needs to be developed and implemented. Information provided by Dr R.F. Parsons and Mr C. Beardsell of the La Trobe University Botany Department, based on their continuing survey of localities of rare and endangered plant species within Victoria, has enabled the development of our present research program on *T. epipactoides*.

This paper, which is based on field studies during 1984–1986, provides a detailed account of the morphological variation, demography, phenology and general ecology of *T. epipactoides* and an introduction to the breeding strategy, highlighting the importance of these aspects in its conservation. Known threats are described in detail and possible courses of action suggested.

A detailed morphological description is provided to quantify the variability of certain characters and accurately define other characters within the species, so as to establish a sound data base on which to study the phenology, demography and pollination ecology of the main Victorian populations.

## STUDY AREAS

The main populations of *T. epipactoides* in Victoria are located within Port Campbell National Park, Bay of Islands Coastal Reserve, Weecurra Flora Reserve near Casterton and at Kiata Flora Reserve near the Little Desert National Park (Fig. 1). Small populations have also been found in recent years in the Grampians region, the Lower Glenelg National Park and within the Gippsland Lakes Coastal Park. The last two populations, however, were not located during 1985–1986.

Port Campbell National Park has a large population of plants (Table 1) distributed along a narrow (less than 50 m wide) strip of open heathland on the top of a sandstone cliff, on the seaward side of the main road east of Port Campbell. The vegetation consists of low (less



Fig. 1. Location of the seven existing populations of *Thelymitra epipactoides* in Victoria. 1, Local Flora Reserve, Kiata. 2, Grampians. 3, Weecurra Flora Reserve, Casterton. 4, Lower Glenelg National Park. 5, Bay of Islands Coastal Park. 6, Port Campbell National Park. 7, Gippsland Lakes Coastal Park.

|                             | Port<br>Campbell | Bay of<br>Islands | Weecurra<br>Flora Reserve |
|-----------------------------|------------------|-------------------|---------------------------|
| Flowering Plants            | 26               | 46                | 37                        |
| Mature Non-flowering Plants | 18               | 163               | 9                         |
| Subtotal (Adult Plants)     | 44               | 209               | 46                        |
| Immature Plants             | 148              | 90                | 20                        |
| Total Plants                | 192              | 299               | 66                        |

Table 1. Number of flowering, mature non-flowering and immature plants recorded for the three main populations of *Thelymitra epipactoides* in Victoria.

than 1 m high) heathland dominated by *Leptospermum scoparium* and *Leucopogon parviflorus*.

The population in the Bay of Islands Coastal Reserve is located in a narrow (less than 100 m wide) coastal strip of vegetation on a cliff top bordered to the north by farmland. This population is widely spread over several kilometres. During 1985 the western section of this population, comprising 209 adult plants (Table 1) growing in grassland dominated by *Themeda*

*australis* and *Poa poiformis*, was studied in detail. The site has not been burned since 1973 (Beardsell 1980–1984) and is being invaded by *Leucopogon parviflorus* and *Leptospermum scoparium*.

The largest inland population of *T. epipactoides* in Victoria, with a total of 66 plants, is located in the Weecurra Flora Reserve near Casterton (Table 1). The population is distributed over two areas: a formerly-grazed paddock reinvaded by *Leptospermum juniperinum*, and a



relatively ungrazed site. The vegetation consists of heathland and sedgeland in which *T. epipactoides* occupies the more open sedgeland.

### BACKGROUND DATA

Beardsell (1980–1984) recorded *T. epipactoides* in a variety of heathy and coastal habitats, although it appeared to survive only in openings between the dominant shrubs. As a means of reducing competition, Beardsell recommended early autumn burning once every five years or grazing during the summer dormant period. The effect of competition is difficult to ascertain because some observations suggest that the orchid can survive several years of strong competition. For example, Beardsell reported the reappearance after 10 years of an individual that had been suppressed by heath at the Bay of Islands Coastal Reserve, and we have seen adult plants growing at the base of recently dead shrubs of *Leucopogon parviflorus* and *Leptospermum juniperinum* that, when alive, would have provided strong competition. It appears that *T. epipactoides* forms part of a disclimax community, possibly maintained by fire. Observations at Weecurra Flora Reserve before and after burns indicate that fire stimulates flowering in the short term and is associated with an increased total number of plants in the long term (Beardsell 1980–1984).

Although collection and habitat loss are historical factors leading to the decline of *T. epipactoides*, Beardsell (1980–1984) noted grazing and competition as important threats to existing populations. An additional, longer term threat is the observed lack of natural pollination (Beardsell 1980–1984; Leigh et al. 1984). At the Bay of Islands Coastal Reserve, for example, Beardsell recorded variable seed set, with many plants producing no seed at all. The only immature plants observed at Port Campbell National Park

during 1985 may be the progeny of hand pollinations by Beardsell in 1981 (pers. comm.). The absence of immature plants at the Bay of Islands Coastal Reserve and Weecurra Flora Reserve, where Beardsell hand pollinated in 1981, may be explained by the lack of suitable microhabitats for seedling establishment.

As yet, *T. epipactoides* has only been found in association with the fungus *Tulasnella asymmetrica* (Warcup & Talbot 1967). This fungus has been found in association with a wide range of common orchids, such as *T. luteocilium*, *T. grandiflora* (now *T. aristata*), *T. nuda* and *T. pauciflora* (Warcup 1973; Warcup & Talbot 1967, 1971). It is unlikely, however, that the absence of the fungus is a factor contributing to the orchid's rarity.

### MATERIALS AND METHODS

At each of three Victorian sites a minimum of 50 plants were chosen at random and their position noted in relation to permanent pegs. Nine floral and vegetative characters were recorded for each individual (Table 2). Certain characters were unavailable in some individuals due to leaf and flower loss resulting from grazing and disease. Each population sample was divided into three size classes: mature/flowering, mature/non-flowering and immature including seedlings. Subsequently we combined the data of each size class from each population to provide an overview of the species variability. All measurements were made using a 250 mm MITUTOYO vernier caliper. All measurements on adult plants, except leaf thickness, were noted during the peak of the flowering period in October. The measurements on the immature plants were collected during August.

Relative humidity was measured using a pocket whirling hygrometer (No. 7765, Negretti and Zambra Ltd, London). Ambient air temper-

| Measured on all plants       | Measured on only one plant |
|------------------------------|----------------------------|
| Leaf length                  | Root tuberoid length       |
| Leaf width                   | Root tuberoid diameter     |
| Leaf thickness               | Root length                |
| Total height                 |                            |
| Length of lower bract        |                            |
| Length of upper bract        |                            |
| Inflorescence length         |                            |
| Number of flowers            |                            |
| Length/Width ratio of tepals |                            |

Table 2. Characters recorded for the morphometric analysis of *Thelymitra epipactoides*.

ature was taken using an electronic temperature sensor (National Semiconductor LM334) enclosed in a small polyvinyl chloride cabinet.

A crossing program involving random selection of 18 (7% of population) flowering plants, each with more than 8 flowers, was conducted at the Bay of Islands Coastal Reserve. Duplicate autogamous, geitonogamous and xenogamous crosses were made on one inflorescence and the flowers sealed with seecotine (E209, Australian Entomological Supplies, Greenwich, NSW), a clear water-based entomological glue. Two more flowers on each inflorescence were sealed, one with the pollinia retained in the anther, to test for cleistogamy, and the other with pollinia removed, an initial test for apomixis. In general no damage was incurred as a result of this treatment, although a few blue-flowered plants incurred minor burns to their tepals from the seecotine. The crosses were inspected at 12, 24, 48, 72, and 96 hours. At each time the post-pollination response of all the crosses was noted and one xenogamous, one geitonogamous and one autogamous cross was collected from the inflorescences of three randomly chosen plants to be inspected subsequently for pollen tube growth (any one plant not being harvested more than once). The series of duplicate crosses remaining on the inflorescence were allowed to mature. Seed from these pollinations was collected in December, dried for several weeks at room temperature (20–25°C), dessicated for 24 hours and stored at 4°C in sealed jars (method recommended by M. Clements, pers. comm.).

To study the growth of the pollen tubes after crossing, the ovaries and styles of the *T. epipactoides* crosses were initially fixed in FAA (1:1:18 Formalin:Acetic Acid:95% Ethanol) and then prepared and stained with decolourized aniline blue according to the method used by Williams et al. (1982). The squashed tissue was inspected under ultraviolet illumination using an Olympus BH-2 fluorescent microscope, with the BH2-RFL reflected light fluorescence attachment, BP-405 Violet excitation filter, DM-455 and Y-455 dichroic mirror and the Y-475 barrier filter attached.

All insects found on *T. epipactoides* were collected and preserved in 70% ethanol or killed with ether and pinned by standard techniques (see Norris & Upton 1978) for later identification. Random sweeps with a 30 cm insect net (E39, Australian Entomological Supplies, Greenwich, NSW) were taken throughout the flowering season and the collected insects inspected for pollinia before being released.

Identification was carried out using *The Insects of Australia* (CSIRO, 1979) and the taxonomic treatments recommended in that publication.

## RESULTS

### Demography

Within the three populations of *T. epipactoides* the age structure was not discernible because no character or combination of characters adequately separated successive annual cohorts. Fig. 2 indicates the spread of the leaf width and thickness for all individuals with intact leaves. All plants with leaf widths greater than 15 mm produced inflorescences in 1985 or showed evidence of inflorescences from a previous season. Leaf width provides a reliable threshold between the immature growth stages of *T. epipactoides* and the mature stages when individuals are capable of flowering. Each population could therefore be divided into mature flowering plants, mature non-flowering plants and immature plants on the basis of this character. Other features such as leaf venation and the cross-sectional shape of the leaf also correlated with this grouping (see morphological descriptions below).

During 1985 the spatial clustering of mature and immature plants was noted. Mature plants were more dispersed, approximately 1 plant every 3 metres, in comparison with immature plants which formed compact colonies, often with more than 50 plants per square metre.

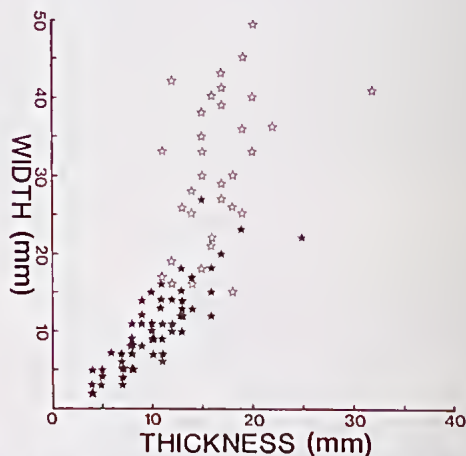


Fig. 2. Ratio of leaf width and thickness for the three main Victorian populations of *Thelymitra epipactoides*. Open stars represent flowering plants, closed stars non-flowering plants.



### Description of *Thelymitra epipactoides*

In the following description morphological data are expressed as ranges delimited by 95% confidence limits, followed by the sample size, the mean and the standard deviation within parentheses. All data show a normal distribution except for the length of the second floral bract ( $X^2 = 12.7125$ ,  $X^2_{P=0.05,6} = 12.592$ ,  $0.05 < P < 0.025$ ). For this character the modes are given. The subterranean parts of only one plant were observed, and hence no variation of below ground characters within the species can be given.

**Flowering Adult Plants.** *T. epipactoides* is a glabrous tuberoid geophyte, 214–644 mm (38, 429  $\pm$  106) high, including inflorescence. Leaf single, erect, lanceolate, 81–398 mm (38, 240  $\pm$  78) long, 17–53 mm (37, 35  $\pm$  9) wide, 0.7–2.4 mm (57, 1.6  $\pm$  0.4) thick, sheathing. Sheath slightly flanged, bases tinged red, not covering base of first bract. Leaf blade with 1–5 prominent keeled veins, the number increasing with size (Fig. 3A).

Root tuberoid obovate, creamy white, length 53 mm, diameter 19 mm, connected to base of stem by short (12 mm), stout (5 mm diameter) connection. Old root tuberoid shrivelled, light brown, length 42 mm, diameter 9 mm. Both root tuberoids surmounted by a ring of roots located at 40 mm below soil surface, varying in length from 60–250 mm with a relatively constant diameter of 3–4 mm, extending to a depth of 200–300 mm. Roots originating from base of cataphyll which covers subterranean tissue of leaf. Cataphyll brown, scarious (Fig. 3B).

Peduncle stout, straight or slightly flexuose with one (occasionally two) stem-clasping bract(s), lower bract 76–318 mm (38, 197  $\pm$  60) long, upper one (when present) of variable length (modes being 0, 70, 105 and 145 mm, in order of decreasing frequency). Inflorescence 76–300 mm (38, 189  $\pm$  55) long, with 7–31 (38, 18.9  $\pm$  6.0) flowers. Each flower with an elliptical to lanceolate acuminate floral bract covering the pedicel and part of the ovary. Flowers resupinate. Ovary inferior, unilocular with parietal placentation, consisting of six segments, the three inner



Fig. 3. A, Adult flowering plant of *Thelymitra epipactoides* on the edge of an open space in *Leptospermum scoparium* and *Leucopogon parviflorus* heathland in the Port Campbell National Park. B, The subterranean parts of *T. epipactoides* from Weecurra Flora Reserve in December 1985; N = new root tuberoid, O = old root tuberoid, S = ground level, R = ring of roots.



segments bearing double placentae, the three outer ones sterile.

Several flower colour morphs are present in each population, ranging from blue to green and brown or even pink. The flower colour of each plant is constant. Detailed inspection of the tepals indicates that the colour results from a mixture of cells with different pigmentation, the final colour being produced by different proportions of the variously coloured cells. Perianth segments elliptical to ovate, rigid, mucronate. Lamina flat in brownish flowers or conspicuously concave in blue-flowered plants, resulting in closed flowers being cylindrical or bulbous respectively. The length and width of the perianth segments decrease up the inflorescence and have a ratio 1.4–2.3 (34,  $1.8 \pm 0.22$ ). Labellum undifferentiated, slightly concave, never becoming fully expanded when the flower opens, remaining horizontal as a platform. Inner surface of all perianth segments covered with unicellular, unbranched trichomes which are pigmented and may contribute to scent production. The combination of these trichomes and the presence of airspaces between the epidermis and mesophyll of the tepals give some plants a characteristic metallic sheen. A sweet smelling scent is produced on days when the flowers are open.

The column is the central structure of the flower and consists of the style, stigma and anther, enveloped by wings. These wings are open in front, exposing the stigmatic surface, rostellum and anther point (Fig. 4A, B), and are ornamented with five lobes: two lateral lobes (column arms), two mid-lobes and a post-anther lobe. The two lateral lobes project forward, with their ends covered in numerous multicellular trichomes up to 3 mm long. The two mid-lobes are laminate, produced over the space between the post-anther lobe and the penicillate column arms, and are irregularly lobed to dentate (Fig. 4). The post-anther lobe is laminate, erect, dentate, extending above the trichomes. The column is usually pigmented. The post-anther lobe and mid-lobes are yellow, the wings a lighter tone of green and the small region between them brown. No brown or green pigmentation occurs on the column of the blue flowered plants. The penicillate column arms are not pigmented.

The style and the anther are separate except for the connection at the rostellum. Stigma orbicular with a deep groove behind the rostellum, laminate for the greater part, almost vertical (tissue supported by a thick prominent ridge on the lower surface), produced into a short thick style

at the base connecting to the top of the ovary. Stylar canal open (Fig. 4A). Stigmatic surface covered with wet mucilage underlined with papillae. Androecium situated behind the stigma, only the anther point being exposed. Anther introrse, dehiscing by longitudinal slits and containing a four-lobed pollinium. Staminal filament fused with column wings, basifixed, produced above into a slender acuminate anther point (Fig. 4A, B).

Pollen grains sulcate, prominently reticulate and forming tetrads agglutinated into a four-lobed pollinium. Pollinium pale yellow. Lobes clavate, glued together along the edge closest to the stigma, the two groups fused to a common short stalk, the caudicle, positioned in the groove on the dorsal edge of the stigma and covered by the rostellum (Fig. 4A, B).

The pollinium, when connected to the stigma by the rostellum, partially protrudes from the anther, only becoming free after the rostellum is touched and the caudicle lifted up. The pollinium lobes are vertical in the anther, spreading after removal (Fig. 4A).

*Thelymitra epipactoides* is a perennial species perpetuating by an annually replaced root tuberoid. The orchid is dormant over the summer period, with only the remains of the previous season's leaf and peduncle obvious. The leaf emerges from the ground in early autumn, slowly develops over winter and reaches full size before spring. During this period the inflorescence also develops, reaching full height and flowering in October (early spring). Pollinated flowers develop over the next month to shed seed in early December (Fig. 5).

**Mature non-flowering plants.** These differ from the flowering plants in that they produce a lanceolate to linear-lanceolate, erect, aglaucous leaf, 131–511 mm ( $7, 321 \pm 78$ ) long, 11–30 mm ( $7, 21 \pm 4$ ) wide, 0.3–2.7 mm ( $7, 1.5 \pm 0.5$ ) thick, with 3–5 prominent keels. Leaf not sheathing. Cataphyll obvious at soil level.

**Immature plants.** These produce a linear leaf, usually at an acute angle to the ground (Fig. 6B), and up to 338 mm ( $29, 167 \pm 84$ ) long, 3–14 mm ( $29, 8 \pm 3$ ) wide, 0.2–1.6 mm ( $28, 0.9 \pm 0.3$ ) thick; smaller leaves not keeled, convolute; keel developing and lamina becoming flat as width increases. Grey-green with red at base of leaf, cataphyll usually obvious at soil level. Immature plants grow on open bare patches of soil between the surrounding scrub (Fig. 6A, B), around old *Leptospermum* stumps or on the sides of open

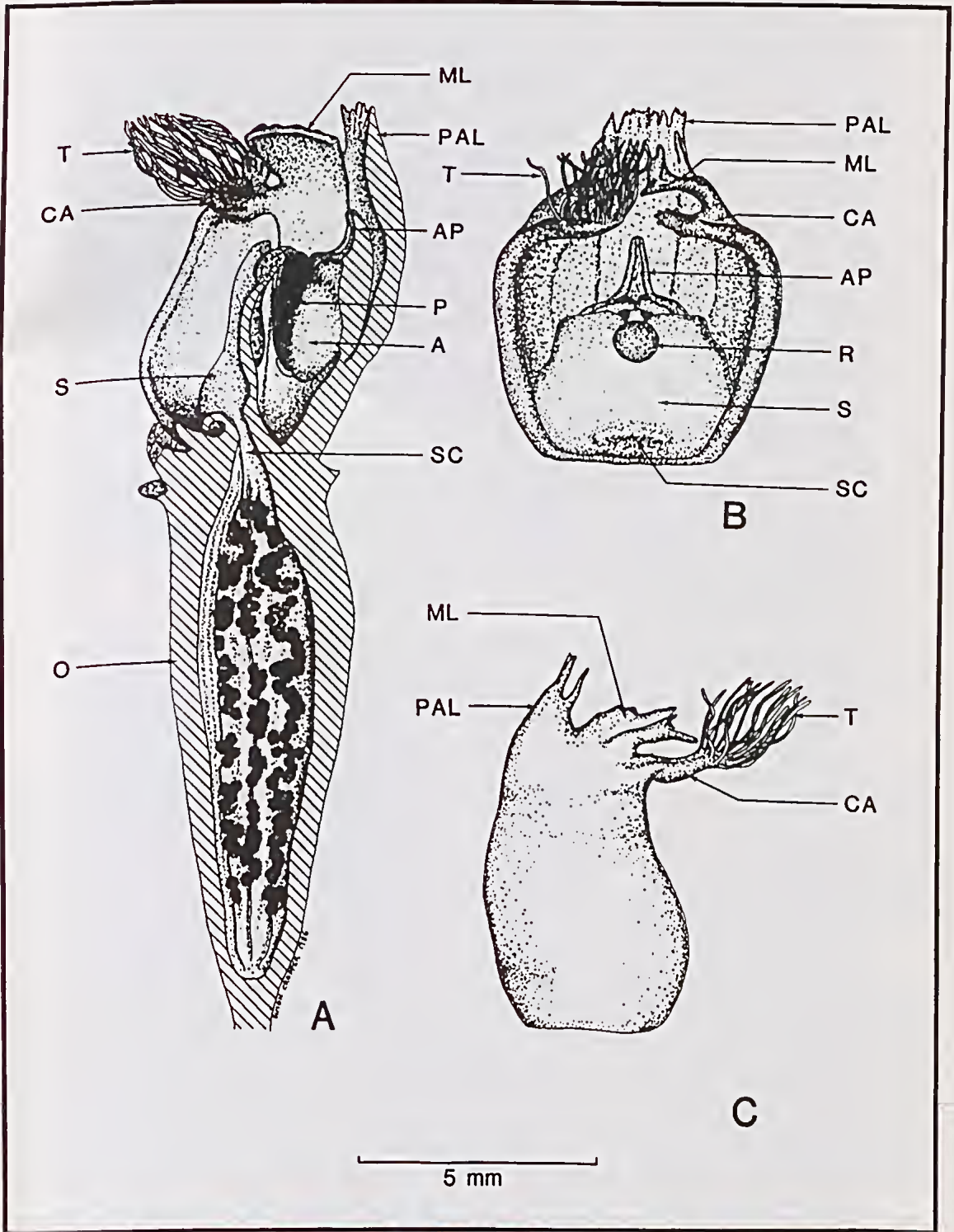


Fig. 4. Ovary and column structure of *Thelymitra epipactoides*. A, Half flower with perianth removed, illustrating the orientation of the anther with respect to the stigma. B, Frontal view of the column. C, Lateral view of the column wings. A = anther, AP = anther point, CA = column arms, ML = midlobe, O = ovary, P = pollinium, PAL = post-anther lobe, R = rostellum, S = stigma, SC = stylar canal, T = trichomes.



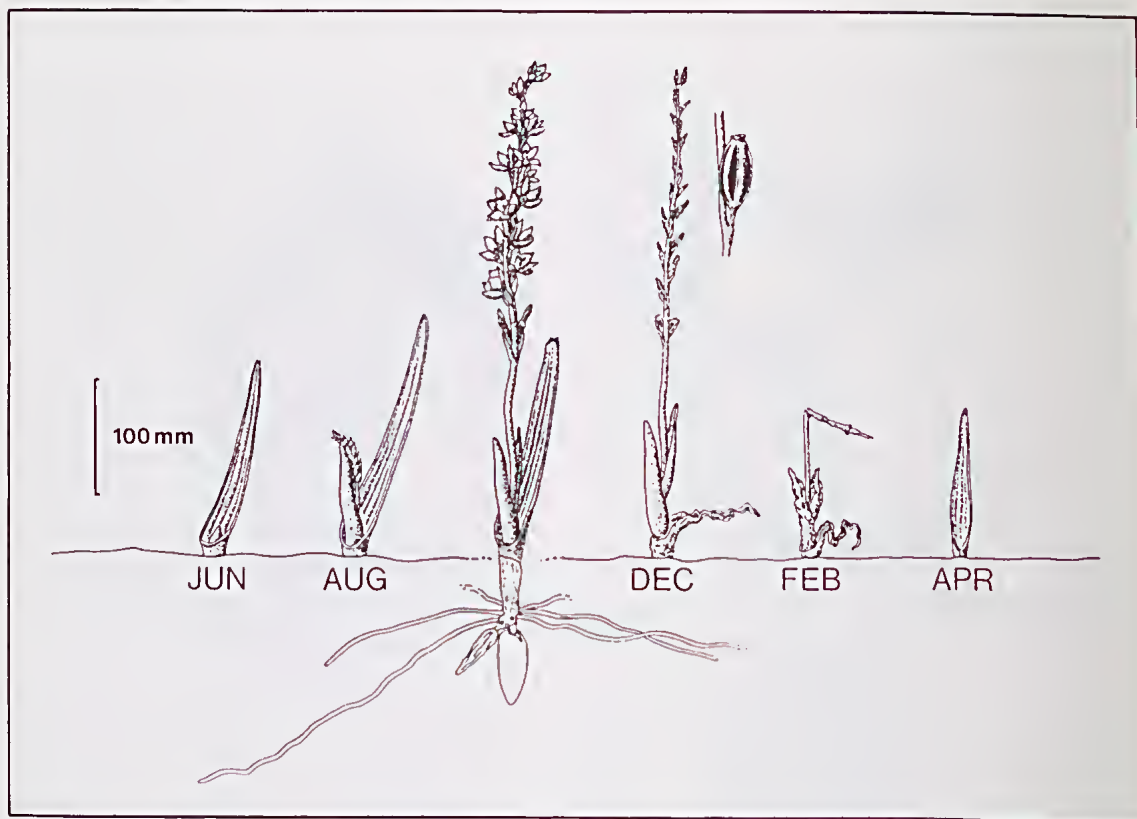


Fig. 5. Annual life cycle of *T. epipactoides*. Note that the plant is dormant from January to March.

paths. At Port Campbell National Park open patches of soil were created after salt pruning of the *Leptospermum* shrubs. The soil surface pH at the Victorian sites varied from 5.6 to 7.5 during December 1985, saturated soils being approximately neutral whereas the better-drained soils were slightly acidic.

**Flowering period.** The main flowering period is during October. Flower opening appears to be a complex process involving responses to sunlight, temperature and humidity. In general, flowers open when the relative humidity is lower than 52%, air temperature is above 15°C, and skies are essentially clear. During October 1985 only 6 days were noted in which such conditions prevailed and flowers opened.

**Breeding strategies.** No detectable physiological difference was observed between autogamous, geitonogamous and xenogamous crosses. All produced seed at the same time and showed no difference in the rate of growth or development

of pollen tubes. Studies on the progeny of xenogamous and autogamous crosses are currently being carried out in conjunction with the Australian National Botanic Gardens, Canberra to reveal any deleterious effects of inbreeding. The crosses designed to test forleistogamy and apomixis did not produce seed, indicating that mechanical self pollination and parthenogenesis respectively do not occur in this species.

At Weecurra Flora Reserve, native bees, the most likely pollinators, were recorded during 1985 when 35% (a total of 109) of the ungrazed flowers formed capsules and set seed. On the coast no natural pollination was recorded. Despite careful observation no bees were seen in the vicinity or observed working typically bee-pollinated plants within a kilometre of the populations. Numerous types of flies including hoverflies were recorded, mainly feeding on flowering *Leptospermum scoparium*.

**Threats.** The Port Campbell population faces a variety of threats of which severe grazing is the most obvious. Grazers include chrysomelid



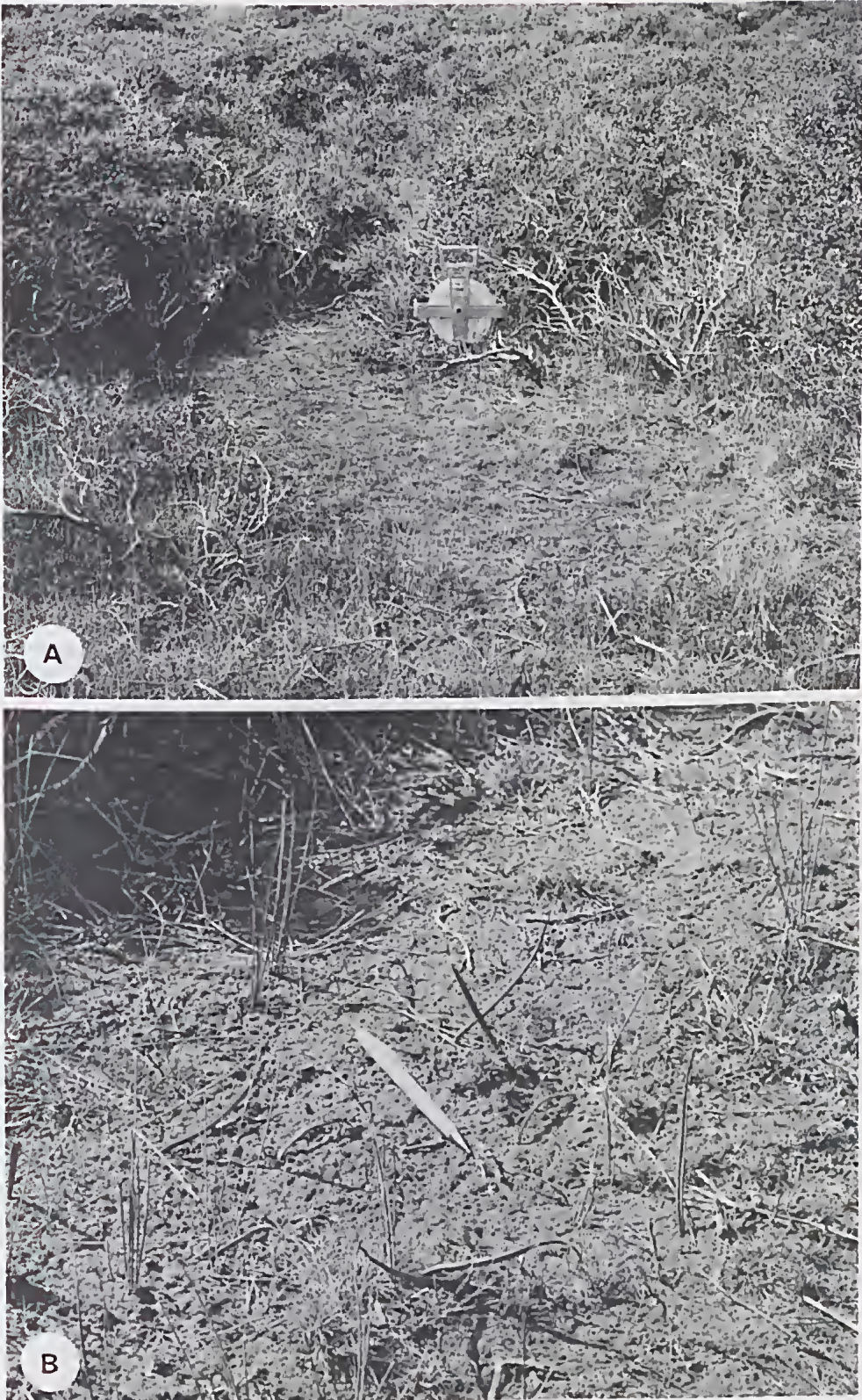


Fig. 6. A, Open space in heathland in which adults and immature plants of *Thelymitra epipactoides* are found, Port Campbell National Park. B, Detail of open space showing immature plants of *T. epipactoides* on bare soil with *Baumea juncea* and *Carex* spp.



|   | Port<br>Campbell | Bay of<br>Islands | Weecurra   |
|---|------------------|-------------------|------------|
| <b>A Damage to plants</b>               |                  |                   |            |
| Grazing                                 |                  |                   |            |
| Chrysomelid beetle larvae               | 52               | 2                 |            |
| Tortricid moth larvae                   |                  |                   | 12         |
| Macropods                               | 45               |                   | 23         |
| Rabbits                                 |                  | 4 <sup>1</sup>    |            |
| Slugs                                   | 1                |                   |            |
| Dieback                                 | 27               | 21                |            |
| Infections                              |                  |                   |            |
| Fungal                                  | 6                |                   |            |
| Bacterial                               | 2                | 12                |            |
| Waterlogging                            | 7                |                   |            |
| Burnt leaf tip, due to late burns       |                  |                   | 11         |
| Physical damage by man                  | 1                |                   |            |
| <i>Total number of plants inspected</i> | 128              | 44                | 50         |
| <b>B Threats to populations</b>         |                  |                   |            |
| Competition                             |                  |                   |            |
| Shrubs                                  | ?                | yes               | previously |
| Grasses                                 | no               | yes               | no         |
| Reduced pollination rate                | yes              | yes               | no         |
| Illegal collection 1985                 | ?                | yes               | ?          |

<sup>1</sup>This number likely to be an underestimate because we selected areas with low rabbit numbers.

Table 3. A, Number of *Thelymitra epipactoides* plants damaged in three Victorian sites during 1985/86 (numbers based on a random sub-sample of population). B, Threats to population survival of *Thelymitra epipactoides* at three Victorian sites.

beetle larvae (Family Chrysomelidae, subfamily Chrysomelinae), rabbits, kangaroos and slugs; by the end of the season 66% of the population was heavily grazed (Table 3). The adult orchids were grazed predominantly by the beetle larvae which appear specific to this species (several specimens have been deposited in the Australian National Insect Collection, voucher number 85-376). The larvae congregate in groups of 4–6 individuals of various ages and ranging in length from 2 to 5 mm. They feed on the tip or the edge of the leaf, working inward and leaving a characteristic jagged edge. If disturbed the larvae drop from the leaf, usually landing within the leaf sheath. Plants were noted with beetle larvae on them as early as 13 August and as late as 8 October. An attacked plant usually lost its leaf within a couple of weeks but no grazing of flowering stems was noted. Grazing by kangaroos was mainly confined to patches of immature plants and corresponded to the general grazing of adjacent grassy areas.

A problem prevalent at both coastal sites but not elsewhere was leaf dieback. This affected the distal parts of the leaf resulting in shrivelling and loss of leaf tissue, eventually leading to total destruction of the leaf as the season progressed. The process has not been investigated but appeared to be quite distinct from normal senescence.

In 1985 a large proportion of the Weecurra Flora Reserve population was grazed by kangaroos and tortricid moth larvae (Family Tortricidae, Subfamily Oleothreutinae). The moth larvae typically tie together the edges of the leaf and eat the interior. On some plants the inflorescence was also eaten. Eastern grey kangaroos (*Macropus giganteus*) were observed at the site, although a number of other kangaroos and wallabies are also known to be in the area. The orchid population was not grazed prior to the commencement of flowering but was severely grazed afterwards, causing a large loss of potential seed. Plants were afforded some protection



adjacent to crowns of *Xanthorrhoea minor*, whose rigid angular leaves discouraged close grazing. Despite the heavy grazing of the inflorescence in this population of *T. epipactoides*, 35% of the flowers set seed in 1985.

## DISCUSSION

It is essential that the phenology of a plant is known before the environments where it grows can be effectively managed. *Thelymitra epipactoides* is a perennial plant and individuals rely on root tuberoids as their only means of perpetuation. Nutrient assimilation is dependent both on the orchid with its single leaf and, to an unknown extent, on the mycorrhizal associate *Tulasnella asymmetrica*. The leaf is exposed for approximately 9 months of the year, the orchid becoming dormant during the summer/autumn dry season.

None of the Victorian populations could be divided into age cohorts on the basis of vegetative characters, although only the larger plants produced flowers.

The stimulus for flowering is unknown. Wells (1981) showed that for *Spiranthes* sp. the total rainfall and earth temperature (at 300 mm) during winter is positively correlated with the percentage of plants flowering, and that summer rainfall is of importance for *Herminium*, both of these being British terrestrial orchids. Gill & Groves (1981) discussed the role of ethylene in increasing flower response in a variety of monocotyledons after fire. The affect of these factors on the associated mycorrhizal fungus is unknown. Historical records of *T. epipactoides* and other orchids (Gill & Groves 1981) describe increased flowering after fire. This could be due to increased nutrient availability to the orchid resulting from a flush of mycorrhizal fungi or release of ethylene. Both of these could be further modified by the climatic requirements of the orchids.

Observations on plants subject to competition from shrubs or grasses suggest that leaf size and flowering are related to nutrient levels and light availability. At the Bay of Islands site, where the vegetation has not been burned since 1973, the population consists largely of non-flowering mature plants. It seems likely that reduced photosynthesis due to shading by vigorous grasses has resulted in inadequate replenishment of the tuberoid for flowering to occur.

*Thelymitra epipactoides* is potentially a prolific seed producer even though the flowers are

open only occasionally during the short flowering season. Contrary to the belief that temperature is the major factor influencing flower opening in *Thelymitra* (Beardsell & Bernhardt 1982; Bernhardt & Burns-Balogh 1986), data collected in this study indicate that low humidity is also an important factor.

When the flowers of *T. epipactoides* open they form an attractive multi-flowered display with a sweet perfume. The flower appears to provide no reward for visiting pollinators and the insect is duped into visiting the raceme. A form of deception, floral mimicry, has been reported in two other *Thelymitra* species, *T. nuda* (Bernhardt & Burns-Balogh 1986) and *T. antennifera* (Dafni & Calder 1987), and possibly also in *T. pauciflora* (J. Armstrong, unpublished data 1986). These species appear to mimic similar-coloured plants which bloom at the same time and provide nectar or pollen for collection. Batesian mimicry such as this requires that the mimic has a lower population density than the model and has relatively constant flower colour. *T. epipactoides* does not appear to mimic the blooms of other plants but maintains a deception by maximizing both the total floral display and variability of flower colour, thus promoting insect visitation and movement. The flower provides sign stimuli to elicit a search response, which results in the removal of the pollinium. Potential pollinators respond to the visual and olfactory display in a way similar to their response to other unfamiliar flowering plants.

The lack of pollination on the coast is possibly due to the local absence of the natural pollinator.

At Bay of Islands Coastal Reserve and Weecurra Flora Reserve seedling recruitment into the *T. epipactoides* population is low. This is probably due to the lack of disturbed soil such as that found near man-made tracks, soil slips, animal tracks and old echidna diggings. Although not recorded in the literature, we have found *T. pauciflora*, *T. nuda*, *T. aristata* and *T. mathewsii* in addition to *T. epipactoides* on recently disturbed sites. It is possible that many *Thelymitra* are essentially colonizing species.

The immediate effect of grazing on a plant is the reduction of leaf area resulting in loss of photosynthetic capability. Under these conditions the orchid may become more dependent on the associated mycorrhizal fungus for nutrients and energy. It is possible that continued heavy grazing may so reduce the resources of the tuber that it is no longer viable. Whether a plant of *T. epi-*

*pactoides* can be sustained by its mycorrhizal associate for several years is unknown.

Threats to the survival of the species have been identified as reduction of habitat, grazing and removal from the wild by collectors. Although these threats are not major problems for extant populations, they have resulted in an increased risk of extinction through overall reduction in numbers. It is possible that reduced breeding success is linked with habitat destruction through the removal of native pollinators.

### *Management and conservation procedures*

Previous burns at Wecurra Flora Reserve have shown that fire promotes flowering and often precedes major recruitment events (Beardsell 1980–1984). Fire also reduces competition from shrubs and grasses, leading to an increase in population numbers. In a natural fire regime the vegetation communities are maintained as open heathlands or grasslands with numerous open sites. The observations at Port Campbell National Park suggest that open patches of bare soil are required for germination and early development of this orchid.

The frequency of fire is extremely important for long term population survival, the appropriate period between fires depending on the floristic composition of the associated community. The aim should be to maintain the vegetation cover at a level at which a population of *T. epipactoides* is not detrimentally affected. As a general management plan, Beardsell (1980–1984) recommended that populations in heathland should be burned every 5–10 years and those in grasslands every 3–4 years. Burns should occur between January and March, the dormant period of the orchid, subject to local fire safety.

At some localities, two barriers to seedling recruitment may exist: lack of pollination and lack of suitable sites for seedling establishment. If a population of *T. epipactoides* has not been pollinated for several years there may be a case for artificial pollination as a means of increasing potential seedling recruitment. In areas with a high level of disturbance from a range of causes, suitable sites are available for seedling establishment provided the disturbance is not excessive or continuous. In areas not permitted to burn, disturbance suitable for seedling establishment may not occur naturally and suitable regimes will need to be established. Ideally, all competitive vegetation should be removed from small areas (1–2 m<sup>2</sup>) and the soil left fallow for several months before seed is released.

The reduction or elimination of grazing poses some problems for managers. Although the exclusion of cattle and sheep at major sites has been achieved through erection of new fences and the withdrawal of grazing leases (as recommended by Beardsell 1980–1984), the threat from rabbits has not been removed, resulting in the partial loss of the populations at Port Campbell National Park and at the Bay of Islands Coastal Reserve (Beardsell 1980–1984). In addition, a population of 82 plants (many of them seedlings) within the Bay of Islands Coastal Reserve were totally eaten by rabbits between August and October 1985, and it is possible that a number of other sites within these reserves were heavily grazed by rabbits during this study. Future burns will lead to a reduction of feed and the movement of rabbits farther from their warrens in search of food, possibly resulting in increased grazing of *T. epipactoides*. The only way of preventing this is through erection of rabbit-proof exclosures around the orchids or by appropriate rabbit control programs.

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